M. Sc. CSIT
Third Semester
Syllabus

Cyber Security and Ethical Hacking

Title: Cyber Security and Ethical Hacking
Course No: CSIT.611
Nature of the Course: Theory + Lab
Semester: III

Full Marks: 60 + 40
Pass Marks: 30 + 20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of cyber security and ethical hacking. The course includes the concepts of cyber security, cyber security attacks, security governance, ethical hacking, and ethical hacking phases including reconnaissance, scanning, enumeration, vulnerability assessment and system hacking.

Course Objectives:
The course aims to achieve the following objectives:

- Introduce concepts of cyber security
- Provide ethical hacking.
- Familiarize phases of ethical hacking.
- Perform reconnaissance, scanning and enumeration.
- Perform Vulnerability assessment.

Unit I: Introduction to Cyber Security (9 Hrs.)
Cyberspace, Cybersecurity; Cyber Security Objectives; Standards for Information Security; NIST Cybersecurity Framework; CIS Security Controls for Cyber Defense; COBIT for Information Security; PCI Data Security Standard; ITU Security Documents; Cybersecurity Management Process; Security Governance and Management; Security Governance Principles; Security Governance Components; Security Governance Approach; Security Governance Evaluation; Cybersecurity Threats and Attacks; Cyber Threat Intelligence; Cyber Attack Protection; Cyber Kill Chain; Security Incident Management Framework and Process; Cyber Law: Global and Local

Unit II: Basics of Ethical Hacking (5 Hrs.)
Hacking; Ethical Hacking; Types of Hacking; Hackers; Types of Hacker; Hacking Phases; Tactics, Techniques and Procedures; Adversary Behavioral Identification; Compromise Indicators

Unit III: Footprinting and Reconnaissance (8 Hrs.)
Concepts of footprinting and reconnaissance; Footprinting through Search Engines, Web Services, Social Networking Sites; Website Footprinting; Email Footprinting; Whois Footprinting; DNS Footprinting; Network Footprinting; Footprinting through Social Engineering; Tools used for Footprinting; Footprinting Countermeasures

Unit IV: Network Scanning (7 Hrs.)
Concepts of Network Scanning; Scanning Tools; Host Discovery; Port and Service Discovery; Operating System Discovery; Scanning Beyond IDS and Firewall; Network Scanning Countermeasures

Unit V: Enumeration (7 Hrs.)
Concepts of Enumeration; NetBIOS Enumeration; SNMP Enumeration; LDAP Enumeration; NTP and NFS Enumeration; SMTP and DNS Enumeration; Enumeration Countermeasures

Unit VI: Vulnerability Assessment (5 Hrs.)
Concepts of Vulnerability Assessment; Vulnerability Classification and Assessment Types; Tools for Vulnerability Assessment; Vulnerability Assessment Reports

Unit VII: System Hacking (4 Hrs.)
Gaining Access to the System; Escalating Privileges; Maintaining Access; Clearing Logs

Laboratory Work:
The laboratory work includes implementing the concepts in above mentioned chapters using various tools of ethical hacking.

Text / Reference Books:

1. William Stallings, Effective Cyber Security, Addion-Wesley, 2019
2. EC-Council, Ethical Hacking and Countermeasures, Academia Series, 2022
3. Dale Meredith, Certified Ethical Hacker (CEH) v11 312-50 Exam Guide, Packt Publishing, 2022

Deep Learning

Course Title: Deep Learning **Full Marks:** 60+40
Course No: CSIT.612 **Pass Marks:** 30+20
Nature of the Course: Theory + Lab **Credit Hrs:** 3
Semester: III

Course Description:

This course introduces fundamental concepts of deep learning, including artificial neural networks, optimization techniques, convolutional networks, recurrent networks, and generative models.

Course Objectives:

By the end of this course, students will be able to:

- Understand the Fundamentals of Deep Learning.
- Develop and Train Neural Networks.
- Optimize and Improve Deep Networks.
- Implement Convolutional Neural Networks (CNNs) for Image Processing.
- Work with Recurrent Neural Networks (RNNs) and Sequence Models.
- Explore Deep Generative Models.

Course Contents:

Unit 1: Introduction to Deep Learning (6 Hrs)

1.1. Artificial Intelligence vs. Machine Learning vs. Deep Learning, Biological Neural Networks vs. Artificial Neural Networks, Neural Networks and Deep Learning, Applications of Deep Learning,

1.2. Models of Neuron (Deterministic vs Stochastic Model), Activation Functions (Threshold, Linear, Sigmoid, Tanh, ReLU, Leaky ReLU, Softmax), Neural Network Architectures, Learning Principles.

1.3. Perceptron, Perceptron Learning Rule, Perceptron Learning Algorithm, Realizing AND/OR Functions with Perceptron, Limitation of Perceptron.

Unit 2: Multilayer Perceptron (10 Hrs)

2.1. Gradient Descent and its Variations, Multilayer Perceptron (MLP), Derivation of Backpropagation, Backpropagation Algorithm.

2.2. Learning Rate, Learning Rate Decay, Gradient Descent Optimizers (Momentum, Adagrad, Adadelta, RMSProp, Adam).

2.3. Loss Functions (MSE, Cross-Entropy), Vanishing and Exploding Gradient Problems, Batch Normalization, Regularization Techniques (L1, L2, Dropout), Cross Validation, Bias variance Tradeoff.

Unit 3: Convolutional Neural Networks (8 Hrs)

3.1. Basics of Image Processing for Deep Learning, Basic Structure of CNN (Convolutional Layer, Pooling Layer, Fully Connected Layer, padding Stride)

3.2. Interleaving Between Layers, Local Response Normalization Hierarchical Feature Engineering, Training Convolutional neural Networks, Data Augmentation.

3.3. CNN Architectures (LeNet, AlexNet, VGG, ResNet), Pretrained Models, Transfer Learning, Applications of CNN.

Unit 4: Recurrent Neural Networks (RNNs) and Sequence Models (10 Hrs.)

4.1. Sequential Data and Time-Series Processing, Expressiveness of Recurrent Network, Architecture of RNN, Limitations of RNNs.

4.2. Backpropagation Through Time, Bidirectional RNNs, Challenges of Training RNNs and Layer Normalization

4.3. Vanishing and Exploding Gradient Problem, Long Short-Term Memory (LSTM) Networks, Gated Recurrent Units (GRUs).

4.4. Applications of RNNs, Attention Mechanism and Transformer Networks

Unit 5: Competitive Learning and Deep Generative Models (8 Hrs.)

5.1. Kohonen Self-Organizing Map, Vector Quantization, Autoencoders (Basic, Denoising, Variational)

5.2. Generative Adversarial Networks (GANs), Training GAN, Comparision with VAE, Using GANs for Generating Images, Conditional GAN.

Unit 6: Deep Reinforcement Learning (6 Hrs.)

6.1. Basics of Reinforcement Learning, Basic Framework of Reinforcement Learning, Challenges of Reinforcement Learning Simple Reinforcement Learning for Tic-Tac-Toe.

6.2. Q-Learning and Deep Q Networks (DQN), Policy Gradient Methods, Applications of Reinforcement Learning.

Laboratory Works:

The laboratory work consists of hands-on experiments, assignments, and projects using **Python, TensorFlow, Keras, and PyTorch**. The lab sessions focus on implementing deep learning models, training networks, and analyzing performance.

Recommended Books

1. Neural Networks and Deep Learning by *Charu C. Aggarwal*
2. Fundamentals and Theory:Deep Learning by *Ian Goodfellow, Yoshua Bengio, and Aaron Courville*
3. Neural Networks and Learning Machines by *Simon Haykin*
4. Deep Learning with Python by *François Chollet*
5. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow by *Aurélien Géron*

Term Paper

Course Title: Term Paper
Course No: CSIT.613
Nature of the Course: Seminar
Semester: III

Full Marks: 50
Pass Marks: 25
Credit Hrs: 2

Course Description:

The term paper is a critical component of this course. It aims to encourage in-depth exploration of a topic related to computer science and information technology. Students are expected to demonstrate critical thinking, research skills, and academic writing abilities. It can be done in many ways like "Literature Review", "Scientific Report", "Research Paper" or a combination of two or more.

Course Objectives:

By the end of this term paper, students will:

- Conduct independent research on a chosen topic.
- Analyze and synthesize relevant literature.
- Develop a structured argument or thesis statement.
- Write and format an academic paper according to accepted standards.
- Improve their citation and referencing skills.

Term Paper Format

1. Cover Page.
2. Letter of Approval
3. Letter of Recommendation
4. Acknowledgement
5. Abstract
6. Table of Content
7. Introduction.
8. Literature Review.
9. Methodology (if applicable).
10. Discussion/Results and Analysis.
11. Conclusion.
12. References.

Referencing and Citation: IEEE

M. Sc. CSIT
Fourth Semester
Syllabus

Web Intelligence

Course Title: Web Intelligence
Course No: CSIT.621
Nature of the Course: Theory + Lab
Semester: IV

Full Marks: 60+40
Pass Marks: 30+20
Credit Hrs: 3

Course Description:

The course begins by introducing the foundations of web intelligence and the challenges of working with large-scale, dynamic web data. It then delves into web structure mining, focusing on algorithms like PageRank and HITS for link analysis and community detection. In web content mining, students will learn to extract structured and unstructured data, perform text mining, and conduct sentiment analysis. The web usage mining section addresses the discovery of user behavior patterns through log analysis, clustering, and personalization techniques.

Course Objectives:

By the end of this course, students will:

- Understand the Foundations of Web Intelligence
- Analyze and Extract Insights from Web Structures
- Mine and Analyze Web Content
- Discover Patterns from Web Usage Data
- Explore Advanced Applications of Web Data Mining

Course Contents

Unit 1: Web Mining (10 Hrs)

1.1. Basic Concepts of Information Retrieval: Information Retrieval Models, Boolean Model, Vector Space Model, Statistical Language Model, Relevance Feedback, Evaluation Measures

1.2. Text and Web Page Pre-Processing: Stopword Removal, Stemming, Other Pre-Processing Tasks for Text, Web Page Pre-Processing, Duplicate Detection,

1.3. Inverted Index and Its Compression: Inverted Index, Search Using an Inverted Index, Index Construction, Index Compression.

1.4. Latent Semantic Indexing,: Singular Value Decomposition, Query and Retrieval, An Example.

1.5. Web Search, Meta-Search: Combining Multiple Rankings, Web Spamming: Content Spamming, Link Spamming, Hiding Techniques, Combating Spam

Unit 2: Social Network Analysis (8 Hrs)

2.1. Social Network Analysis: Centrality and Prestige, Co-Citation and Bibliographic Coupling

2.2. PageRank Algorithm, Strength and Weaknesses of Page Rank Algorithm, Timed PageRank and Recency Search.

2.3. HITS Algorithm: Finding Other Eigenvectors, Relationships with Co-Citation and Bibliographic, Coupling, Strengths and Weaknesses of HITS.

2.4. Community Discovery: Problem Definition, Bipartite Core Communities, Maximum Flow Communities, Email Communities Based on Betweenness, Overlapping Communities of Named Entities.

Unit 3: Web Crawling (8 Hrs)

3.1. A Basic Crawler Algorithm: Breadth-First Crawlers, Preferential Crawlers.

3.2. Implementation Issues: Fetching, Parsing, Stopword Removal and Stemming, Link Extraction and Canonicalization, Spider Traps, Page Repository Concurrency.

3.3. Universal Crawlers: Scalability, Coverage vs Freshness vs Importance, Focused Crawlers, Topical Crawlers, Evaluation.

Unit 4: Opinion Mining and Sentiment Analysis (9 Hrs.)

4.1. The Problem of Opinion Mining, Document Sentiment Classification, Sentence Subjectivity and Sentiment Classification, Opinion Lexicon Expansion

4.2. Aspect-Based Opinion Mining, Mining Comparative Opinions, Some Other Problems.

4.3. Opinion Search and Retrieval, Opinion Spam Detection, Utility of Reviews

Unit 5: Web Usage Mining (10 Hrs.)

4.1. Data Collection and Pre-Processing, Data Modeling for Web Usage Mining, Discovery and Analysis of Web Usage Patterns.

4.2. Recommender Systems: The Recommendation Problem, Content-Based Recommendation, Collaborative Filtering using KNN, Association Rules and Matrix Factorization.

4.3. Query Log Mining: Data Sources, Characteristics, and Challenge, Query Log Data Preparation, Query Log Data Models, Query Log Feature Extraction, Query Log Mining Applications, Query Log Mining Methods.

Laboratory Works

The laboratory component of the Web Intelligence course focuses on hands-on practice with web data mining techniques and tools. Students will work on a series of practical tasks and mini-projects designed to reinforce the concepts covered in the syllabus. The labs will involve programming, data analysis, and real-world applications using web data.

Text/ Reference Books:

1. Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data by Bing Liu
2. Mining the Web: Discovering Knowledge from Hypertext Data by Soumen Chakrabarti
3. Social Media Mining: An Introduction by Reza Zafarani, Mohammad Ali Abbasi, and Huan Liu
4. Data Mining: Concepts and Techniques by Jiawei Han, Micheline Kamber, and Jian Pei

Dissertation

Course Title: Dissertation
Course No: CSIT.622
Nature of the Course: Thesis
Semester: IV

Full Marks: 200
Pass Marks: 100
Credit Hrs: 8

Course Description:
This course covers the research based activities of computer science and information technology. The course focuses on enabling students with the skills related to research methodology with state of art technologies. The course includes performing design, implementation and analysis of problems and findings in computer science and information technology.

Course Objectives:
The course aims to achieve the following objectives:

- Familiarize with the ideas of research methodology.
- Acquire theoretical and practical research skills.
- Conduct research allied to computer science and information technology.

Phases of the Dissertation work:

a. **Proposal Defense:** Project proposal should be submitted and defended at the start of dissertation work.

b. **Mid-Defense:** Pre-defense of the work should be conducted before final submission. The format and content hierarchy of the mid-defense report should be the same as the final report. Every student must qualify mid-defense before at least two to three weeks of the final defense.

c. **Final Defense:** Final defense of the dissertation work should be conducted as a part of qualification of the dissertation work. The final report should be submitted to the department before at least a week of the final defense date.

Evaluation Scheme:
The evaluation committee and evaluation criteria should be as follow;

a. **Evaluation committee for Proposal Defense**
   - A research committee with HOD of the department should evaluate the proposal defense of dissertation work. Every student should qualify proposal defense before starting the work.

b. Evaluation committee for Mid-Defense

- An evaluation committee with HOD, Supervisor and Internal Examiner should evaluate the mid-defense of the dissertation work

c. Evaluation Committee for Final Defense

- An evaluation committee with HOD, Supervisor, Internal Examiner and External Examiner should evaluate the final defense of the dissertation work. The external examiner should be assigned from the exam section of the dean's office.

d. Evaluation Description

S.N.	**Description**	**Full Marks**
1	Overall Dissertation Work	50
2	Presentation of Dissertation Work	40
3	Report Documentation of Dissertation Work	50
5	Abstract and Conclusion	20
6	Citations/References	10
7	Viva-Voce	30
	Total	**200**

e. Cumulative Marks

Head/Director/Coordinator = 10 % of 200
Supervisor = 60% of 200
Internal Examiner = 10% of 200
External Examiner = 40% of 200

Final Marks = 200

Report Content Hierarchy:

a. Contents of the proposal

1. Introduction
2. Problem Statement
3. Objectives
4. Scope and Limitation
5. Background Study and Literature Review
6. Methodology
    a. Description of Methodology
    b. Flowcharts Depicting Methodology (If Any)
    c. Description of Data (If any)
    d. Description of Mathematical Models and Algorithms
    e. Performance / Evaluation Metrics (If any)
7. Working Schedule
8. Expected Outcome
9. References
10. Plagiarism Test Report

b. Contents of the final report

1. Cover & Title Page
2. Certificate Page
    a. Supervisor Recommendation
    b. Head, Supervisor, Internal and External Examiners' Approval Letter
3. Acknowledgement
4. Abstract Page
5. Table of Contents
6. List of Abbreviations, List of Figures, List of Tables, etc.
7. Main Report
8. References
9. Bibliography (If Any)
10. Appendices (If any)
11. Plagiarism Test Report

c. Chapters in the main report

1. Chapter 1: Introduction (May include introduction, problem statement, objectives, scope and limitation, report organization, etc.)
2. Chapter 2: Background Study and Literature Review(May include background study, literature study, etc.)

3. **Chapter 3: Methodology** (May include concepts like description of methodology, data sets, mathematical models, algorithms, performance measures, etc.)
4. **Chapter 4: Implementation and Result Analysis** (May include description of the tools and techniques used, details of implementation, findings and observations, result analysis, etc.)
5. **Chapter 6: Conclusion and Future Recommendations** (May include the conclusion of research work and future directions, etc.)

The concepts in above mentioned chapters should be contextualized with the respective problem domain while doing the work. All the reports should qualify the plagiarism test standard as set by the dean office.

Citation and Referencing:

The listing of references should be listed in the references section. The references containing the list of articles, books, web urls, etc. should be cited and listed in IEEE referencing format. The resources that are studied and referred during the study but not cited in the report should be listed in the bibliography section.

Formatting Guidelines:

The report can be prepared using a word processor or LATEX. The students are highly encouraged to use LATEX. The formatting standards should be followed as below;

- The pages from certificate page to the list of tables should be numbered in roman starting from i while the pages from chapter 1 onwards should be numbered in numeric starting from 1. The page number should be inserted at the bottom center.
- The paper size must be A4. The margins must be set as Top = 1 inch, Bottom = 1 inch, Left = 1.25 inch, Right = 1 inch
- All paragraphs must be justified and have spacing of 1.5.
- The font face of the contents in the document should be Times New Roman. The font size in the paragraphs of the report should be 12 sizes. The font size for the chapter headings, section headings and sub-section headings should be 16, 14 and 12 respectively. All the headings should be bold faced.
- All the figure and table captions should be of bold face with 12 font size. Position of figures and tables should be aligned in the center. The figure caption should be centred below the figure and table captions should be centred above the table.

Report Binding and Submission:

- Four copies of spiral binding of proposal should be submitted before the proposal defense.

- Three copies of spiral binding of mid-defense report should be submitted before the mid-defense.

- Four copies of spiral binding of the final report should be submitted before the final defense.

- Three signed copies of golden embracing black binding should be submitted as a final submission after the defense.

Quantum Computing

Course Title: Quantum Computing
Course No: CSITE.651
Nature of the Course: Theory + Lab

Full Marks: 60+40
Pass Marks: 30+20
Credit Hrs: 3

Course Description:

This course offers a comprehensive introduction to the exciting field of quantum computing, blending foundational theory with practical applications. Students will delve into topics such as qubits, quantum gates, and quantum circuits, building towards an understanding of key quantum algorithms like Grover's search algorithm and Shor's factorization algorithm. The course also includes hands-on laboratory work using cutting-edge quantum programming frameworks like Qiskit and Cirq, allowing students to design, simulate, and execute quantum circuits.

Course Objectives:

By the end of this course, students will:

- Understand the fundamental principles of quantum computing.
- Learn basic quantum mechanics relevant to computation.
- Explore quantum gates, algorithms, and their applications.
- Gain familiarity with quantum programming frameworks.

Course Contents:

Unit 1: Introduction to Quantum Computing (8 Hrs)

1.1. Why study quantum computing?, Difference between classical and quantum computation, Overview of quantum computing applications.

1.2. Review of Linear Algebra: Vectors and vector spaces, Inner products, outer products, and matrices, Eigenvalues and Eigenvectors.

1.3. Introduction to Quantum Mechanics: Qubits and the concept of superposition, The Bloch sphere representation, Measurement and the collapse of the quantum state.

Unit 2: Quantum Gates and Circuits (12 Hrs)

2.1. Single Qubit Gates: Identity, Pauli-X, Pauli-Y, Pauli-Z gates, The Hadamard gate and its role in superposition, Matrix representation of gates.

2.2. Multi-Qubit Systems: Tensor products and multi-qubit states, Entanglement and Bell states, Quantum measurement in multi-qubit systems.

2.3. Multi-Qubit Gates and Circuits: CNOT gate and controlled operations, Swap gate and Toffoli gate, Designing simple quantum circuits.

Unit 3: Algorithms and Computation **(12 Hrs)**

- **3.1.** Quantum Algorithm Foundations: Quantum parallelism, Probabilities in quantum, measurement, The concept of quantum speedup.
- **3.2.** The Deutsch-Josza Algorithm: Problem setup, Circuit implementation, Advantages over classical approaches.
- **3.3.** Grover’s Search Algorithm: Introduction to unstructured search, Implementation and analysis of Grover’s algorithm.
- **3.4.** Shor’s Algorithm: Overview of integer factorization, Role of quantum Fourier transform, Significance of Shor’s algorithm in cryptography.

Unit 4: Advanced Topics and Applications **(13 Hrs.)**

- **4.1.** Quantum Error Correction: The need for error correction in quantum computing, Quantum error correction codes (e.g., Shor and surface codes).
- **4.2.** Quantum Programming: Introduction to quantum programming languages (e.g., Qiskit, Cirq), Implementing quantum circuits on simulators, Hands-on exercises with simple algorithms.
- **4.3.** Applications of Quantum Computing: Quantum cryptography (e.g., BB84 protocol), Optimization problems and machine learning, Quantum supremacy and current progress in quantum hardware.
- **4.4.** Future of Quantum Computing: Challenges in scaling quantum systems, Research directions and open questions, Ethical considerations in quantum technology.

Laboratory Works

Student should simulate Qubits and Superposition, Single Qubit Gates, Multi-Qubit Systems & Entanglement and Quantum Circuit Design. Moreover, students should implement various algorithms studied in the course. Additionally, the students should be encouraged to simulate quantum error correction codes and BB84 quantum key distribution protocol.

Text/Reference Books:

1. Quantum Computing for Everyone by Chris Bernhardt
2. Quantum Computation and Quantum Information by Michael A. Nielsen and Isaac L. Chuang
3. Explorations in Quantum Computing by Colin P. Williams

4. An Introduction to Quantum Computing by Phillip Kaye, Raymond Laflamme, and Michele Mosca
5. Learn Quantum Computing with Python and Q# by Sarah C. Kaiser and Chris Granade
6. Programming Quantum Computers by Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia
7. The Qiskit Textbook by IBM Quantum (Online Resource)

Natural Language Processing

Title: Natural Language Processing **Full Marks:** 60+40
Course No: CSITE.652 **Pass Mark:** 30+20
Nature of the Course: Theory + Lab **Credit Hrs:** 3

Course Description:
Natural language processing is a subfield of linguistics, computer science, and artificial intelligence concerned with the interactions between computers and human language, in particular how to program computers to process and analyze large amounts of natural language data. This course introduces the concepts of natural language processing including morphological and syntactic analysis, text preprocessing, statistical and neural approaches to natural language processing.

Course Objectives:
This course aims to achieve the following objectives:

- The prime objective of this course is to introduce the students to the field of Language Computing and its applications ranging from classical era to modern context.
- To gain the knowledge of computational linguistics and NLP applications which have huge demands in market (Data science, E-commerce and social media analysis)
- To provide an introduction to the fundamental concepts and techniques of NLP.
- To equip students with the skills to develop NLP-based applications.
- To familiarize students with state-of-the-art tools and research in NLP.

Unit 1: Introduction (5 Hours)
Introduction to NLP, Brief history of NLP research, Challenges in NLP (Difficulties, Ambiguities and Evolution), Knowledge in speech and language processing, Ambiguity, Models and algorithms, Language, Thought, and Understanding, current applications.

Unit 2: Morphological and Syntactic Analysis (6 Hours)
Morphology (Inflectional and Derivational) and Finite-State Transducers: Survey of English morphology - Finite-State Morphological parsing - Combining FST lexicon and rules - Lexicon-Free FSTs: The porter stammer - Human morphological processing.

Unit 3: Text Processing and Representation (7 Hours)
Tokenization, Stemming, Lemmatization, Word Representations: One-hot, TF-IDF, Word Embeddings (Word2Vec, GloVe, FastText), Sentence Embeddings, Preprocessing Techniques.

Unit 4: Statistical NLP (8 Hours)
Language Modeling (n-grams, Markov Chains), Hidden Markov Models (HMM), Probabilistic Context-Free Grammars (PCFG), Named Entity Recognition (NER).

Unit 5: Neural Approaches to NLP (9 Hours)
Recurrent Neural Networks (RNNs) and LSTMs, Attention Mechanisms and Transformers, Pre-trained Models (BERT, GPT, etc.), Sequence-to-Sequence Models, Applications: Machine Translation, Text Summarization.

Unit 6: Applications and Ethics in NLP (6 Hours)
Sentiment Analysis, Chatbots and Conversational Systems, Information Retrieval and Question Answering Ethical Considerations in NLP.

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters.

Text/Reference Books:

1. "Speech and Language Processing" by Daniel Jurafsky and James H. Martin
2. "Deep Learning for Natural Language Processing" by Palash Goyal, Sumit Pandey, and Karan Jain
3. "Foundations of Statistical Natural Language Processing" by Christopher D. Manning and Hinrich Schütze
4. "Neural Network Methods for Natural Language Processing" by Yoav Goldberg
5. "Natural Language Processing with Python" by Steven Bird, Ewan Klein, and Edward Loper

Data Warehousing and Data Mining

Title: Data Warehousing and Data Mining
Course No: CSITE.653
Nature of the Course: Theory + Lab

Full Marks: 60 + 40
Pass Marks: 30 + 20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of concepts data warehousing and data mining. The course includes the concepts of data mining, data warehousing, OLAP, pattern mining, classification, clustering and outlier detection.

Course Objectives:
The course aims to achieve the following objectives:
- Introduce concepts of data mining.
- Provide concepts of data warehousing.
- Familiarize with classification and clustering.
- Acquaint with the concepts of outliers.

Unit I: Introduction (5 Hrs.)
Data Mining, Knowledge Discovery, Data Mining Applications, Data Mining Process, Data Types for Data Mining, Statistics of data, Similarity and Distance Measures, Data Quality, Data Cleaning, Data Integration, Data Transformation, Dimensionality Reduction

Unit II: Data Warehousing and Online Analytical Processing (7 Hrs.)
Data Warehouse, Data Warehouse Modeling: Schema and Measures, OLAP, ROLAP, MOLAP, OLAP Operations, Data Cube Computation**,** Data Cube Computation Methods

Unit III: Pattern Mining (7 Hrs.)
Basic Concepts of Pattern Mining, Frequent Itemset Mining Methods, Pattern Evaluation Methods, Mining Various Kinds of Patterns, Mining Compressed or Approximate Patterns, Constraint-Based Pattern Mining, Mining Sequential Patterns, Mining Subgraph Patterns

Unit IV: Classification (9 Hrs.)
Basic Concepts of Classification, Decision Tree, Bayes Classification Methods, Lazy Learners, Linear Classifiers, Model Evaluation and Selection, Techniques to Improve Classification Accuracy, Feature Selection and Engineering, Bayesian Belief Networks, Support Vector Machines, Rule-based and Pattern-based Classification, Classification with Weak Supervision, Classification with Rich Data Type

Unit V: Cluster Analysis (9 Hrs.)
Cluster Analysis, Partitioning Methods, Hierarchical Methods, Density-Based and Grid-Based Methods, Evaluation of Clustering, Probabilistic Model-Based Clustering, Clustering High-

Dimensional Data, Biclustering, Dimensionality Reduction for Clustering, Clustering Graph and Network Data, Semisupervised Clustering

Unit VI: Outlier Detection (8 Hrs.)

Basic Concepts of Outlier Detection, Statistical Approaches, Proximity-based Approaches, Reconstruction-based Approaches, Clustering vs. Classification-based Approaches, Mining Contextual and Collective Outliers, Outlier Detection in High-dimensional Data

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters.

Text books/ References:

1. Jiawei Han, Jian Pei, Hanghang Tong, Data Mining: Concepts and Techniques, The Morgan Kaufmann Series in Data Management Systems, 4th Edition, 2022
2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, Introduction To Data Mining, Pearson, Second Edition, 2019
3. Prateek Bhatia, Data Mining and Data Warehousing: Principles and Practical Techniques, Cambridge University Press, 2019

Multimedia Computing

Title: Multimedia Computing
Course No: CSITE.654
Nature of the Course: Theory + Lab

Full Marks: 60+40
Pass Mark: 30+20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of fundamental principles of multimedia systems. This course covers different aspects including concepts, component and applications of multimedia in various domains; Fundamentals of data representation; Image compression, Digital audio and video processing techniques, Multimedia over IP networks, Content-based image and video retrieval, Emerging Trends in Multimedia Computing.

Course Objectives:
This course aims to achieve the following objectives:

- Understand the fundamental principles of multimedia systems.
- Learn multimedia data representation, compression, and processing techniques.
- Develop skills for multimedia content creation, analysis, and retrieval.
- Gain knowledge of multimedia networking and applications.
- Introduce to advanced and emerging trends in multimedia computing.

Unit 1: Introduction to Multimedia (5 Hours)

Definitions and concepts of multimedia; Components of multimedia: Text, Image, Audio, Video, and Animation; Applications of multimedia in various domains; Multimedia systems and architecture

Unit 2: Multimedia Data Representation and Compression (10 Hours)

Fundamentals of data representation: Bitmap, Vector, and Audio formats; Image compression: JPEG, PNG, GIF; Video compression: MPEG, H.264; Audio compression: MP3, AAC

Unit 3: Multimedia Content Creation and Processing (8 Hours)

Digital audio and video processing techniques; Tools for multimedia content creation; Image and video editing software (e.g., Photoshop, Premiere Pro); Basics of animation and 3D modeling

Unit 4: Multimedia Networking and Communication (7 Hours)

Multimedia over IP networks; streaming protocols: RTP, RTSP; Quality of Service (QoS) in multimedia communication; Content delivery networks (CDNs)

Unit 5: Multimedia Information Retrieval (6 Hours)

Content-based image and video retrieval; Indexing and searching multimedia databases; Relevance feedback and multimedia search engines

Unit 6: Emerging Trends in Multimedia Computing (4 Hours)

Virtual Reality (VR) and Augmented Reality (AR); Interactive multimedia applications; AI and Machine Learning in multimedia

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters.

Text/ Reference Books

1. Ze-Nian Li and Mark S. Drew, Fundamentals of Multimedia, 2nd Edition, Springer.
2. Tay Vaughan, Multimedia: Making It Work, 9th Edition, McGraw-Hill Education.
3. Fred Halsall, Multimedia Communications: Applications, Networks, Protocols, and Standards, Pearson.
4. Ramesh Jain, Multimedia Computing, Springer.
5. David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson.

Image Processing

Course Title: Image Processing
Course No: CSITE.655
Nature of the Course: Theory +Lab

Full Marks: 60+40
Pass Marks: 30+20
Credit Hrs: 3

Course Description:
This course covers the investigation, creation and manipulation of digital images by computer. The course consists of theoretical material introducing the mathematicsof images and imaging. Topics include representation of two-dimensional data, time and frequency domain representations, filtering and enhancement, the Fourier transform, convolution, interpolation. The student will become familiar with Image Enhancement, Image Restoration, Image Compression, Morphological Image Processing, Image Segmentation, Representation and Description, and Object Recognition.

Course Objectives:
The objective of this course is to make students able to:

- Develop a theoretical foundation of Digital Image Processing concepts.
- Provide mathematical foundations for digital manipulation of images; image acquisition; preprocessing; segmentation; Fourier domain processing; and compression.
- Gain experience and practical techniques to write programs for digital manipulation ofimages; image acquisition; pre-processing; segmentation; Fourier domain processing; and compression.

Course Content:
Unit 1: Introduction (5 Hrs.)
Digital Image, A Simple Image Model; Fundamental steps in Image Processing; Element of visual perception; Sampling and Quantization; Some basic relationships like Neighbors

Unit 2: Image Enhancement and Filter in Spatial Domain (8 Hrs.)
Basic Gray Level Transformations: Point operations, Contrast Stretching, Clipping and Thresholding; Histogram Processing; Spatial Operations: Basics of Spatial Filtering, Linear filters, Spatial Low Pass Smoothing Filters, Averaging, Weighted Averaging, Non-Linear Filters; Magnification.

Unit 3: Image Enhancement in the Frequency Domain (8 Hrs.)
Introduction to Fourier Transform and the Frequency Domain; Properties of Fourier Transform; Smoothing Frequency Domain Filters; Sharpening Frequency Domain Filters; Fast Fourier Transform; Other Image Transforms.

Unit 4: Image Restoration and Compression (8 Hrs.)
Image Restoration: Introduction, Models for Image Degradation and Restoration Process, Noise Models; Restoration Filters; Image Compression; Image Compression Models.

Unit 5: Introduction to Morphological Image Processing (3 Hrs.)
Introduction to Logic Operations involving Binary Images, Introduction to Morphological Image Processing; Morphological Operations.

Unit 6: Image Segmentation (8 Hrs.)
Introduction; Discontinuity Based Techniques: Point Detection, Line Detection, Edge Detection using Gradient and Laplacian Filters; Similarity based techniques.

Unit 7: Representations, Description and Recognition (6 Hrs.)
Introduction to some descriptors: Chain codes, Signatures, Shape Numbers, Fourier Descriptors; Recognition; Pattern Recognition.

Laboratory Work:
Students are required to develop programs in related topics using suitable programming languages such as MatLab or Python or other similar programming languages.

Text / Reference Books:

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Edition, Latest Edition.
2. I. Pitas, "Digital Image Processing Algorithms", Prentice Hall, Latest Edition.
3. A. K. Jain, "Fundamental of Digital Image processing", Prentice Hall, Latest Edition.
4. K. Castlemann, "Digital image processing", Prentice Hall of India Pvt. Ltd., Latest Edition.
5. P. Monique and M. Dekker, "Fundamentals of Pattern Recognition", LatestEdition.

Computational Geometry

Title: Computational Geometry
Course No: CSITE.656
Nature of the Course: Theory + Lab
Full Marks: 60 + 40
Pass Marks: 30 + 20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of concepts of computational geometry. The course includes the introducing the concepts for solving problems using geometric structures. The course includes concepts of geometric objects, intersection problems, point inclusions, convex hull, Voronio diagrams, path planning problems and mesh structures.

Course Objectives:
The course aims to achieve the following objectives:

- Introduce concepts of computational geometry
- Provide concepts of geometric data objects
- Familiarize with intersection and inclusions problems
- Acquaint with the concepts of polygon triangulation
- Understand configuration of convex hulls in 2D and 3D
- Provide concepts of proximity problems
- Simulate collision free shortest path for robots
- Generate mesh structures from complex geometric objects.

Unit I: Introduction (6 Hrs.)
Computational Geometry, Combinatorial vs, Numerical Computational Geometry, Geometric Objects: Point, Line Segment, Line, Point Line Classification, Polygon: Convex, Non-Convex, Diagonal Existence in Polygon, Polygon Triangulation, Triangulation Dual, Ear and Mouth of Polygon, Three Coloring of Polygon, Art Gallery Problem, Left and Right Turns, Computation of Area of Polygon

Unit II: Segment Intersection and Point Inclusion (5 Hrs.)
Line Segment Intersection, Proper and Improper Intersection, Determining Segment Intersection using Plane Sweep Algorithm, Point Inclusion Problem, Methods for Point Inclusion Test: Turn Test, Ray Casting

Unit III: Polygon Triangulation (8 Hrs.)
Triangulation of Polygon, Diagonal of Polygon, Diagonal Test using Turn Test, Approaches for Polygon Triangulation: Diagonal Based, Ear Removal, Polygon Partitioning, Monotone Partitioning, Triangulation of Monotone Polygon, Plane Sweep Algorithm for Monotone Partitioning, Convex Partitioning Problem

Unit IV: Convex Hull (9 Hrs.)

Convex Hull Problem, Convex Hull in 2D, Convex Hull in 3D, Algorithms for Convex Hull in 2D: Extreme Point, Extreme Edge, Gift Wrap, Quick Hull, Grahm’s Scan, Divide and Conquer, Incremental, Data Structure for 3D: Doubly Connected Edge List, Algorithms for Convex Hull in 3D: Gift Wrap, Divide and Conquer, Incremental

Unit V: Proximity Problems (7 Hrs.)

Basics of Proximity Problems, Voronio Polygon, Voronoi Diagram, Applications of Voronio Diagram, Construction of Voronoi Diagrams, Delaunay Triangulation, Largest Empty Circle Problem, Nearest Neighbor Problem, Range Search Problems, One Dimensional and Higher Dimensional Range Searches

Unit VI: Robot Motion Planning (6 Hrs.)

Motion Planning, Path Planning Problem, Visibility Graph, Finding Collision Free Path using Visibility Graph, Motion Planning of a Point Robot, Minkowski Sum, Motion Planning of Disc Robot and Polygonal Robot

Unit VII: Mesh Generation (4 Hrs.)

Mesh, Types Mesh: Structured, Unstructured, Hybrid, Triangular, Quadrilateral, Mesh Conformity and Mesh Validity, Global Vertex Numbering, Mesh Generation Approaches: Topology Decomposition, Geometric Decomposition, Delaunay Triangulation Based Decomposition, Quad Tree Decomposition,

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters using appropriate programming language.

Text books/ References:

1. Jacob E. Goodman, Joseph O’Rourke, Csaba D. Tóth, Handbook of Discrete And Computational Geometry, CRC Press, 2018
1. J.O' Rourke, Computational Geometry in C, Cambridge University Press
2. Mark de Berg, Otfried Cheong, Marc van Kreveld, and Mark Overmars, Computational Geometry: Algorithms and Applications, Springer Berlin Heidelberg
3. Handbook of Computational Geometry, JR Sack, J. Urrutia, Elsevier.

Cloud and Distributed Computing

Course Title: Cloud and Distributed Computing **Full Marks:** 60+40
Course No: CSITE.657 **Pass Marks:** 30+20
Nature of the Course: Theory + Lab **Credit Hrs:** 3

Course Description:
The course introduces the concepts of cloud computing, technological platforms for cloud, cloud computing mechanisms, cloud architectures, distributed computing concepts, and emerging trends in cloud computing.

Course Objectives:
The course aims to achieve the following objectives:

- Introduce concepts of cloud computing
- Implement and simulate various cloud platforms
- Understand mechanisms in cloud computing
- Conceptualize and adapt cloud architectures
- Understand concepts of distributed computing
- Use distributed file system environments
- Familiarize with the trending concepts in cloud

Course Contents:

Unit 1: Introduction (7 Hrs.)
Cloud, Cloud Characteristics, Cloud Computing, Impact of Cloud Computing, Ethical Issues in Cloud Computing, Factors affecting Cloud Computing Service Availability, Virtualization, Types of Virtualization, Impact of Virtualization in Cloud Computing, Containerization, Cloud Service Models: SaaS, PaaS, IaaS, XaaS, Cloud Deployment Models: Public, Private, Community, Multi-cloud, Hybrid

Unit 2: Technology Platforms (8 Hrs.)
Hypervisors, Dockers, AWS, Google Clouds, Azure, IBM Clouds, Aneka

Unit 3: Cloud Computing Mechanisms (8 Hrs.)
Cloud Infrastructure Mechanisms, Logical Network Perimeter, Virtual Server, Hypervisor, Cloud Storage Device, Cloud Usages Monitor, Resource Replication, Ready-made Environment, Container, Automated Scaling Listener, Load Balancer, SLA Monitor, Pay-Per-Use Monitor, Audit Monitor, Failover System, Resource Cluster, Multi-Device Broker, State Management Database

Unit 4: Cloud Computing Architecture (10 Hrs.)
Cloud Architectures: Workload Distribution, Resource Pooling, Dynamic Scalability, Elastic Resource Capacity, Service Load Balancing, Elastic Disk Provisioning, Redundant Storage and Multi-cloud, Hypervisor Clustering, Virtual Server Clustering, Load-Balanced Virtual Server Instances, Non-disruptive Service Relocation, Zero Downtime, Cloud Balancing, Resilient Disaster Recovery Distributed Data Sovereignty, Resource Reservation, Dynamic Failure

Detection and Recovery, Rapid Provisioning, Storage Workload Management , Virtual Private Cloud

Unit 5: Distributed Computing (7 Hrs.)
Parallel and Distributed Computing, Elements of Parallel Computing, Elements of Distributed Computing, Technologies for Distributed Computing, Distributed Algorithms for Cloud: Load Balancing, Fault Tolerance, Consensus, Leader Election, Mutual Exclusion, Map Reduce, Grid Computing, Grid Architecture, Distributed File Systems, NFS, AFS, Google File System (GFS), Hadoop Distributed File System (HDFS), Object Storage

Unit 6: Emerging Trends in Cloud (45 Hrs.)
Edge Computing, Fog Computing, Machine Learning on Clouds, Quantum Computing on Clouds, Vehicular Clouds, Cloud Native Development, FinOps, Low-Code/No-Code Platforms

Laboratory Works:
The laboratory work should include the implementation and simulation of the concepts mentioned in above chapters.

Text/ Reference Books:

1. Thomas Erl, Eric Barcelo Monroy, Cloud Computing: Concepts, Technology, and Architecture, 2nd Edition, Pearson, 2024
2. Dan C. Marinescu, Cloud Computing Theory and Practice, 3rd Edition, Morgan Kaufmann Publishers, 2022
3. Raj Kumar Buyya, Christian Vecchiola, S. ThamaraiSelvi, Mastering Cloud Computing Foundations and Applications Programming, Morgan Kaufmann Publishers
4. Web resources for Hypervisors, Dockers, AWS, Google Clouds, Azure, IBM Clouds, Aneka

Big Data Analytics

Title: Big Data Analytics
Course No: CSIT.658
Nature of the Course: Theory + Lab

Full Marks: 60+40
Pass Mark: 30+20
Credit Hrs: 3

Course Description:

This course is designed to provide students with a comprehensive understanding of fundamental concepts of big data analytics. This course covers different aspects including Introduction to Big Data, Evolution of Big Data, Challenges with Big Data, Framework for Big Data Analysis, Approaches for big data analysis, Big Data Analytics for Policy and Decision-Making, Big Data Storage, Hadoop Eco systems, Map Reduce: Anatomy of a Map Reduce Job Run.

Course Objectives:

The objectives of the course are to:

- Understand business decisions and create competitive advantage with Big Data analytics
- Explore the fundamental concepts of big data analytics.
- Learn to analyze the big data using intelligent techniques.
- Understand the various search methods and visualization techniques.
- Learn to use various techniques for mining data stream.
- Understand the applications using Map Reduce Concepts.
- Introduce programming tools PIG & HIVE in Hadoop echo system.
- Understand the financial value of big data analytics

Unit 1: Introduction to Big Data (10 Hrs.)

Big Data, Types of Digital Data, Characteristics of Data, Evolution of Big Data Definition of Big Data, Challenges with Big Data ,3Vs of Big Data, Big Data Generation-Enterprise Data, IoT Data, Internet Data, Bio-medical Data, Data Generation from Other Fields, Big Data Acquisition, Data Collection, Data Transportation, Data Pre-processing. Relationship Between IoT and Big Data and Hadoop, Big Data applications

Unit 2: Big Data Analytics (5 Hrs.)

Introduction to Big Data Analytics, Framework for Big Data Analysis, Approaches for big data analysis, ETL in Big Data. Understanding Text Analytics and Big Data, Predictive Analysis on Big Data, Role of Data Analyst,

Unit 3: Big Data Storage (5 Hrs.)

Storage System for Massive Data, Distributed Storage System, Storage Mechanism for Big Data - Database Technology, Design Factors, Database Programming Model

Unit 4: Hadoop Ecosystem (15 Hrs.)

Hadoop Eco systems, Hive, Architecture, data type, File format, HQL, SerDe – User defined function, Pig: Features -Anatomy, Pig on Hadoop, Pig Philosophy, Pig Latin overview, Data types – Running pig – Execution modes of Pig – HDFS commands – Relational operators – Eval Functions – Complex data type – Piggy Bank.

Unit 5: Map Reduce (5 Hrs.)
Map Reduce, Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features

Unit 6: Business Intelligence (5 Hrs.)
Introduction to Business Intelligence, Business View of IT Applications, Digital Data, Introduction to Online Analytical Processing & OLAP vs OLTP. Business Intelligence Concepts: BI roles and responsibilities, BI framework and components, BI Project life cycle, Business Intelligence vs Business Analytics.

Text/ Reference Books:

1. Seema Acharya &Subhashini Chellappan, Big data and Analytics, Wiley publishers
2. Anand Rajaraman and Jeff Ullman, “Mining of Massive Datasets”, Cambridge University Press,
3. Alex Holmes “Hadoop in Practice”, Manning Press, Dreamtech Press.
4. Dan McCreary and Ann Kelly, “Making Sense of NoSQL” – A guide for managers and the rest of us, Manning Press.
5. Minelli M., Chambers M., Dhiraj A., Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for today’s Businesses, Wiley CIO, 2013.
6. Big Data Black Book by DT Editorial Services, Dreamtech Publications 2015.

Embedded Systems

Course Title: Embedded Systems
Course No: CSITE.659
Nature of the Course: Theory + Lab
Full Marks: 60+40
Pass Marks: 30+20
Credit Hrs: 3

Course Description:

This course introduces the fundamental concepts of embedded systems, focusing on ARM Cortex-M microcontrollers. Students will learn to program microcontrollers in Assembly and C, understand hardware/software interfacing, and design embedded solutions for real-world problems.

Course Objectives:

By the end of this course, students will:

- Understand the architecture of ARM Cortex-M microcontrollers.
- Develop proficiency in programming microcontrollers using Assembly and C.
- Learn about peripheral interfacing, communication protocols, and real-time systems.
- Design and implement embedded systems for practical applications.

Course Contents:

Unit 1: Introduction to Embedded Systems (4 Hrs)

1.1. Definition and applications of embedded systems, ARM Cortex-M microcontroller architecture overview.

1.2. Key features of Cortex-M processors, Embedded development environment setup (Keil uVision, STM32Cube, etc.).

Unit 2: ARM Cortex-M Microcontroller Architecture (6 Hrs)

2.1. ARM architecture and programmer's model, General-purpose registers and special function registers.

2.2. Memory organization: Flash, SRAM, and peripheral registers, Assembly language basics and instruction set.

Unit 3: Programming in Assembly and C (6 Hrs)

3.1. Introduction to ARM assembly language, writing, compiling, and debugging assembly programs.

3.2. Introduction to embedded C programming, Linking Assembly and C: Mixed-language programming.

Unit 4: GPIO and Input/Output Interfacing (6 Hrs.)

4.1. Configuring GPIO pins for input/output, Interfacing switches and LEDs

4.2. Debouncing techniques, Hands-on: Blinking an LED and controlling switches.

Unit 5: Timers and Interrupts (6 Hrs.)

5.1. ARM Cortex-M timer modules and their configuration, Using SysTick timer. Interrupt handling in Cortex-M.

5.2. Nested Vector Interrupt Controller (NVIC), Hands-on: Timer-based LED control and interrupt-driven applications.

Unit 6: ADC, DAC, and Sensor Interfacing (6 Hrs.)

6.1. Introduction to ADC and DAC, Configuring ADC for analog signal sampling.

6.2. Interfacing temperature, light, or motion sensors, Hands-on: Displaying sensor data on an LCD.

Unit 7: Communication Protocols (5 Hrs.)

7.1. UART, SPI, and I2C basics, Configuring communication interfaces in Cortex-M.

7.2. Hands-on: Serial communication between microcontroller and PC, Hands-on: Interfacing EEPROM using I2C.

Unit 8: Real-Time Operating Systems (6 Hrs.)

8.1. Introduction to RTOS and task scheduling, Basics of FreeRTOS, Implementing tasks, semaphores, and queues.

8.2. Hands-on: Multi-tasking applications using FreeRTOS.

Laboratory Works

Students design, implement, and present an embedded system project. Some of the sample project examples are Smart home device, wearable device, or sensor network.

Text/Reference Books

1. Embedded Systems with Arm Cortex-M Microcontrollers in Assembly Language and C by Yifeng Zhu
2. Embedded Systems Fundamentals with ARM Cortex-M based Microcontrollers: A Practical Approach by Alexander G Dean
3. Embedded Systems: Introduction to Arm® Cortex™-M Microcontrollers by Jonathan W Valvano

Digital Governance

Title: Digital Governance **Full Marks: 60+40**
Course No: CSITE.660 **Pass Mark: 30+20**
Nature of the Course: Theory + Lab **Credit Hrs: 3**

Course Description:
This course is designed to provide students with a comprehensive understanding of concept of ICT and e-governance. This course covers different aspects including fundamentals of digital governance, models for digital governance, smart cities and ICT innovation, Open Data Policies and Practices, Big Data Analytics for Policy and Decision-Making, Artificial Intelligence in Governance, Block chain for Transparency and Accountability, Future Directions: Web 3.0, Metaverse, and Quantum Computing, Challenges and Risks in Digital Governance and Implementation Strategies and Best Practices.

Course Objectives:
This course aims to achieve the following objectives:

- Provide a comprehensive understanding of digital governance frameworks and practices.
- Equip students with the knowledge to analyze and implement ICT-driven governance models.
- Explore the role of emerging technologies in governance transformation.
- Foster critical thinking about challenges, opportunities, and ethical implications in digital governance.

Course Contents:

Unit 1: Fundamentals of Digital Governance (6 hours)
Introduction to Digital Governance and Public Administration, Concept of governance and digital transformation, Role of ICT in digital governance, Evolution from Traditional to Digital Governance, Objectives and Scope of Digital Governance, Global Trends and Benchmarking (e.g., UN E-Government Survey)

Unit 2: Frameworks and Models of Digital Governance (6 hours)
Theoretical Frameworks of Digital Governance, Models: e-Administration, e-Service, e-Participation, Digital Maturity Models and Stages of Implementation, Case Studies: Estonia, South Korea, India

Unit 3: ICT for Digital Governance (6 hours)
Role of Information and Communication Technology in Public Services, Components of E-Government Infrastructure, Role of social media in governance and public participation, Cyber security and privacy concerns in digital governance, Smart Cities and ICT Innovations in Urban Governance, Digital Platforms for Citizen Engagement

Unit 4: Data Governance and Ethics (6 hours)

Introduction to Data Governance in Public Sector, Open Data Policies and Practices, Big Data Analytics for Policy and Decision-Making, Ethical Concerns: Data Privacy, Security, and Sovereignty

Unit 5: Emerging Technologies in Digital Governance (6 hours)
Artificial Intelligence in Governance: Opportunities and Risks, Block chain for Transparency and Accountability, Internet of Things (IoT) in Public Infrastructure Management, Future Directions: Web 3.0, Metaverse, and Quantum Computing, Role of quantum computing in secure digital governance.

Unit 6: Challenges and Risks in Digital Governance (6 hours)
Cyber security: Threats to Governance Systems, Legal and Regulatory Challenges in ICT Implementation, Bridging the Digital Divide: Inclusion and Accessibility, Organizational and Cultural Resistance to Digital Transformation

Unit 7: Implementation Strategies and Best Practices (6 hours)
Planning and Execution of Digital Governance Initiatives, Monitoring, Evaluation, and Feedback Mechanisms, Funding and Partnerships for Sustainable Digital Projects, Best Practices from Developed and Developing Countries

Unit 8: Special Topics and Emerging Issues (3 hours)
Digital Diplomacy and International Cooperation, Environmental Sustainability in Digital Governance, Crisis Management and Digital Governance

Laboratory Work:
The laboratory work includes implementing the concepts in above mentioned chapters as well as preparing case study reports and group project related to the digital governance.

Text/ Reference Books

1. Digital Government: Technology and Public Sector Performance by Darrell M. West
2. The Oxford Handbook of Digital Technology and Society by William H. Dutton
3. E-Government and Information Management by Laura Alcaide Muñoz and Manuel Pedro Rodríguez Bolívar
4. Reports: UN E-Government Survey, OECD Digital Government Studies
5. Journals: Government Information Quarterly, International Journal of Electronic Government Research

Digital Marketing and Digital Economy

Title: Digital Marketing and Digital Economy
Course No: CSITE.661`
Nature of the Course: Theory + Lab

Full Marks: 60 + 40
Pass Marks: 30 + 20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of digital marketing and digital economy. The course includes introducing the concepts of digital marketing, search engine optimization, email marketing, digital economy, financial technology, blockchain technology, and decentralized finance.

Course Objectives:
The course aims to achieve the following objectives:

- Introduce concepts of digital marketing
- Understand the concepts of marketing strategy
- Familiarize with SEO
- Provide concepts of Email marketing
- Acquaint with the concepts digital economy
- Understand block chain technology
- Provide concepts of decentralized finance

Unit I: Introduction (6 Hrs.)
Digital Marketing, Evolution of Digital Marketing, Types of Digital Marketing, Digital Marketing Value, Digital Marketing Mix, Digital Marketing Objectives, Digital Marketing Strategy, Digital Marketing Planning Process, Digital Marketing Strategies and Tactics, Digital Marketing Plan

Unit II: Website Marketing Strategy (6 Hrs.)
Website Evolution and Value, Website Marketing Objectives, Website Marketing Considerations, Website Content Strategies, Website Marketing Analytics

Unit III: Search Engine Optimization and Marketing (7 Hrs.)
Search Engine Optimization (SEO), SEO Objectives, SEO Considerations and Strategies, SEO Content Strategies, SEO Analytics, Search Engine Marketing (SEM), SEM Objectives, SEM Considerations and Strategies, SEM Content Strategies, SEM Analytics

Unit IV: Email Marketing (5 Hrs.)
Email Marketing, Email Marketing Objectives, Email Marketing Considerations, Email Marketing Content and Design Strategies, Email Marketing Analytics

Unit V: Introduction to the Digital Economy (7 Hrs.)
Digital Economy, Evolution from Traditional to Digital Economies, Key Drivers of Digital Economy, Forms of Money: Physical vs. Digital Money, Forms of Digital Money

(Cryptocurrencies and E-money), Currency Pegs and their role in the Economy, Digital Market Platforms: Economic Practices in Digital Age, Search Engines, Social Media, E-commerce, Online Gaming Economies, Financial Technologies (FinTech): Role of FinTech in the Digital Economy Payment Systems and Digital Banking Innovation

Unit VI: Blockchain Technology (8 Hrs.)

Introduction to Blockchain: Definition, Structure, and Components of Blockchain, Types of Blockchain: Public, Private, Consortium, and Hybrid, Centralization Vs. Decentralization, Permissioned vs. Permissionless, Initial Coin Offering (ICO), Consensus mechanisms: Proof of Work (PoW), Proof of Stake (PoS), and dBFT, Blockchain Applications: Use cases in Search Engines, Social Media, E-commerce Platforms, Online Games, Healthcare, Credit Rating, Smart Contracts: Concept and Use Cases, Bitcoin and Ethereum Ecosystem: Bitcoin: Block Structure, Merkle Tree and Block Header, Nonce, Mining, Wallets, Bitcoin Address and Transactions, Bitcoin Issues: Block Size, Bitcoin Split, Transaction Fees, Bitcoin supply and its future, Ethereum: Introduction, Smart Contracts, Decentralized Applications (dApps), Digital Tokens: Fungible and Non-fungible Tokens (NFTs), Native Tokens, Asset-backed tokens, Contract Tokens, Utility Tokens

Unit VII: Decentralized Finance (DeFi) (5 Hrs.)

Introduction to DeFi, Evolution of DeFi, Problems of Centralized Financial Systems, Traditional Finance Vs. DeFi, DeFi Primitives: Transactions and Custody in DeFi, Supply Adjustment, Swap, and Incentives, Collateralized and Uncollateralized Loans, DeFi Infrastructure: Role of Blockchain in Enabling DeFi, Cryptocurrency, Smart Contract Platform, DeFi Applications: Credit and Lending Platforms, Decentralized Exchanges (DEXs), Derivatives and Tokenization

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters.

Text books/ References:

1. Raj Sachdev, Digital Marketing, McGraw Hill, 2024
2. Ian Dodson, The Art of Digital Marketing, Wiley
3. Antony Lewis, The Basics of Bitcoins and Blockchains, Mango Publishing, 2018
4. Len Mei, Blockchain, Bitcoin, and the Digital Economy, Packt Publishing, 2024
5. Tim Jordan, The Digital Economy, Polity Publishing, 2020
6. Campbell R. Harvey, Ashwin Ramchandran, and Joey Santoro, DeFi and the Future of Finance, Wiley
7. Imran Bashir, Mastering Blockchain, Packt Publishing, 2018
8. Daniel Drescher, Blockchain Basics: A Non-Technical Introduction 25 Steps, Apress, 2017

Information Coding and Theory

Title: Information and Coding Theory
Course No: CSITE.662
Nature of the Course: Theory + Lab

Full Marks: 60+40
Pass Mark: 30+20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of concept of information theory and coding schemes. This course covers different aspects including fundamentals concepts of information theory, data compression and error detection and correction, Huffman coding, arithmetic coding, Channel coding, application of information theory and emerging trends in information theory.

Course Objectives:

This course aims to achieve the following objectives:

- To understand the fundamental concepts of information theory.
- To explore the principles of data compression and error detection/correction.
- To learn about coding schemes for efficient and reliable data communication.
- To analyze applications of information theory in modern communication systems.

Course Outline

Unit 1: Introduction to Information Theory (8 Hours)
Concept of information and entropy; Properties of entropy; Mutual information and its properties; Channel capacity theorem;

Unit 2: Source Coding (8 Hours)
Basics of data compression; Huffman coding; Arithmetic coding; Lempel-Ziv coding; Shannon-Fano coding

Unit 3: Error Detection and Correction (10 Hours)
Introduction to error detection and correction; Linear block codes; Cyclic codes; Hamming codes; BCH codes and Reed-Solomon codes;

Unit 4: Channel Coding (8 Hours)
Introduction to channel coding; Convolutional codes; Trellis diagrams; Viterbi decoding; Turbo codes

Unit 5: Applications and Advanced Topics (6 Hours)
Applications of coding theory in communication systems; Information theory in cryptography; Network coding basics; Emerging trends in information coding

Unit 6: Practical Applications (5 Hours)

Case studies in compression and error correction; Simulation of coding algorithms; Tools for information theory analysis

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters.

Text/ Reference Books:

1. T.M. Cover and J.A. Thomas, Elements of Information Theory, 2nd Edition, Wiley, 2006.
2. R. Bose, Information Theory, Coding and Cryptography, 2nd Edition, Tata McGraw-Hill, 2008.
3. S. Lin and D.J. Costello, Error Control Coding: Fundamentals and Applications, 2nd Edition, Pearson, 2004.
4. T. Richardson and R. Urbanke, Modern Coding Theory, Cambridge University Press, 2008.
5. N. Abramson, Information Theory and Coding, McGraw-Hill, 1963.

Advanced Computer Architecture

Course Title: Advanced Computer Architecture
Course No: CSITE.663
Nature of the Course: Theory + Lab

Full Marks: 60+40
Pass Marks: 30+20
Credit Hrs: 3

Course Description:

This course provides a comprehensive study of modern computer architecture. The course emphasizes quantitative design principles, performance analysis, and optimization techniques used to build high-performance and energy-efficient computer systems. Students will explore the principles of instruction set design, pipelining, memory hierarchy, storage systems, and parallelism at various levels (instruction, thread, and data). The course also covers advanced topics such as dynamic instruction scheduling, multi-core processors and GPU architectures.

Course Objectives:

By the end of this course, students will:

- Understand fundamental concepts of computer architecture and design principles.
- Analyze the performance and cost metrics of computer systems.
- Explore quantitative approaches to processor design, memory hierarchy, and parallelism.
- Gain insight into modern architecture trends like multi-core and GPUs.

Course Contents

Unit 1: Fundamentals of Quantitative Design and Analysis (5 Hrs)

1.1. Trends in Technology, Trends in Power and Energy in Integrated Circuits, Trends in Cost

1.2. Dependability, Measuring, Reporting, and Summarizing Performanc, Quantitative Principles of Computer Design.

1.3. Performance, Price, and Power, Fallacies and Pitfalls,

Unit 2: Memory Hierarchy Design (8 hrs)

2.1. Introduction, Ten Advanced Optimizations of Cache Performance, Memory Technology and Optimizations

2.2. Protection: Virtual Memory and Virtual Machines, Crosscutting Issues: The Design of Memory Hierarchies

2.3. Memory Hierarchies in the ARM Cortex-A8 and Intel Core i7, Fallacies and Pitfalls

Unit 3: Instruction-Level Parallelism and Its Exploitation (14 Hrs)

3.1. Instruction-Level Parallelism: Concepts and Challenges, Basic Compiler Techniques for Exposing ILP

3.2. Reducing Branch Costs with Advanced Branch Prediction, Overcoming Data Hazards with Dynamic Scheduling, Dynamic Scheduling Examples and the Algorithm

3.3. Hardware-Based Speculation, Exploiting ILP Using Multiple Issue and Static Scheduling, Exploiting ILP Using Dynamic Scheduling, Multiple Issue, and Speculation, Advanced Techniques for Instruction Delivery and Speculation

3.4. Studies of the Limitations of ILP, Cross-Cutting Issues: ILP Approaches and the Memory System, Multithreading: Exploiting Thread-Level Parallelism to Improve Uniprocessor Throughput, The Intel Core i7 and ARM Cortex-A8, Fallacies and Pitfalls.

Unit 4: Data-Level Parallelism in Vector, SIMD, and GPU Architectures (10 Hrs.)

4.1. Introduction, Vector Architecture, SIMD Instruction Set Extensions for Multimedia

4.2. Graphics Processing Units, Detecting and Enhancing Loop-Level Parallelism, Crosscutting Issues

4.3. Mobile versus Server GPUs and Tesla versus Core i7, Fallacies and Pitfalls.

Unit 5: Thread-Level Parallelism (8 Hrs.)

5.1. Introduction, Centralized Shared-Memory Architectures, Performance of Symmetric Shared-Memory Multiprocessors

5.2. Distributed Shared-Memory and Directory-Based Coherence, Synchronization: The Basics, Models of Memory Consistency: An Introduction, Crosscutting Issues, Multicore Processors and Their Performance, Fallacies and Pitfalls

Laboratory Works

Students are expected to engage in laboratory work and research projects in the following areas:

- Performance Evaluation: Conduct analysis of a given processor using SPEC benchmarks to assess its performance characteristics.
- Pipeline Simulation: Design and implement a simulation of a pipelined processor using programming languages such as Python or C++.

- Cache Design: Develop and optimize cache parameters to enhance performance for specific workloads.
- Research Project: Investigate and critically analyze recent research papers from prominent conferences such as ISCA or MICRO.

Text/ Reference Books

1. Computer Architecture: A Quantitative Approach by John L. Hennessy and David A. Patterson
2. Computer Organization and Design: The Hardware/Software Interface by David A. Patterson and John L. Hennessy
3. Structured Computer Organization by Andrew S. Tanenbaum and Todd Austin

Advanced Database Management System

Title: Advanced Database Management System
Course No: CSITE.664
Nature of the Course: Theory + Lab

Full Marks: 60+40
Pass Mark: 30+20
Credit Hrs: 3

Course Description:
This course is designed to provide students with a comprehensive understanding of concept of advanced DBMS. This course covers different aspects including concepts and architecture of database system; query processing and optimization, transaction management and concurrency control, distributed and parallel databases, concept of big data and No-SQL databases, database security and privacy, emerging trends in DBMS.

Course Objectives:
This course aims to achieve the following objectives:

- To understand advanced concepts and architectures of database systems.
- To explore query optimization, transaction management, and distributed databases.
- To study the latest trends, including big data, NoSQL, and database security.

Course Contents:
Unit 1: Introduction to Advanced DBMS Concepts (4 Hours)
Overview of Database Systems; Review of Relational Model and SQL; Advanced Data Models: Object-Relational, Temporal, and Spatial Databases; Limitations of Traditional DBMS

Unit 2: Query Processing and Optimization (7 Hours)
Query Processing: Steps and Components; Query Optimization Techniques: Cost-Based and Heuristic; Use of Indexes, Materialized Views, and Query Caching; Performance Tuning and Optimization Tools

Unit 3: Transaction Management and Concurrency Control (7 Hours)
Concepts of Transactions and ACID Properties; Concurrency Control Protocols: Locking, Timestamp, and Optimistic Techniques; Recovery Mechanisms: Checkpoints and Logging; Distributed Transactions and Two-Phase Commit

Unit 4: Distributed and Parallel Databases (8 Hours)
Distributed Database Architecture; Data Fragmentation, Replication, and Allocation; Distributed Query Processing; Parallel Database Systems: Architecture and Optimization

Unit 5: Big Data and NoSQL Databases (8 Hours)
Introduction to Big Data and Hadoop Ecosystem; Overview of NoSQL Databases: Key-Value, Columnar, Document, Graph Databases; Case Studies: MongoDB, Cassandra, Neo4j; Comparison with Relational Databases

Unit 6: Database Security and Privacy (5 Hours)
Threats to Databases and Security Models; Authentication, Authorization, and Encryption; SQL Injection Attacks and Prevention; Privacy-Preserving Techniques

Unit 7: Emerging Trends in DBMS (6 Hours)
Cloud Databases: Amazon RDS, Google Cloud Spanner; In-Memory Databases: Redis, SAP HANA; Blockchain and Databases; Future Directions: AI-Driven Database Systems

Text / Reference Books

1. "Database System Concepts" by Abraham Silberschatz, Henry F. Korth, and S. Sudarshan
2. "Advanced Database Systems" by Carlo Zaniolo et al. Focus on advanced architectures and distributed systems.
3. "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence" by Pramod J. Sadalage and Martin Fowler Practical insights into NoSQL databases.
4. "Hadoop: The Definitive Guide" by Tom White Key resource for understanding Big Data concepts and Hadoop.
5. "Fundamentals of Database Systems" by Ramez Elmasri and Shamkant B. Navathe Strong foundation for advanced database topics.

Internet of Things

Title: Internet of Things
Course No: CSITE.665
Nature of the Course: Theory + Lab

Full Marks: 60 + 40
Pass Marks: 30 + 20
Credit Hrs: 3

Course Description:

This course tries to present a broad view of the IoT. It presents, in a coherent way, new ideas to explore in the IoT ecosystem, trying to encompass the presence of heterogeneous communication technologies through unifying concepts such as interoperability, discoverability, security, and privacy. On the way, it also touches upon cloud and fog computing (two concepts interwoven with IoT) and conclude with a practical view on IoT (with focus on the physical devices).

Course Objectives:

- To understand the fundamental concepts of IoTs.
- To apply tools and techniques for IoTs applications development.
- To develop interoperable systems with security and privacy.

Course Contents:

1. **Preliminaries, Motivation, and Related Work** **(2 Hrs.)**
    1.1 What is the Internet of Things?
    1.2 Wireless Ad-hoc and Sensor Networks: The Ancestors without IP
    1.3 IoT-enabled Applications
        1.3.1 Home and Building Automation
        1.3.2 Smart Cities
        1.3.3 Smart Grids
        1.3.4 Industrial IoT
        1.3.5 Smart Farming

2. **Standards** **(7 Hrs.)**
    2.1 Traditional Internet Review
    2.2 The Internet of Things
    2.3 The Industrial IoT

3. **Interoperability** **(7 Hrs.)**
    3.1 Applications in the IoT
    3.2 The Verticals: Cloud-based Solutions
    3.3 REST Architectures
    3.4 The Web of Things
    3.5 Messaging Queues and Publish/Subscribe
    3.6 Session Initiation for the IoT
    3.7 Performance Evaluation
    3.8 Optimized Communications: the Dual-network Management Protocol

4. **Discoverability** **(6 Hrs.)**
   4.1 Service and Resource Discovery
   4.2 Local and Large-scale Service Discovery
   4.3 Scalable and Self-configuring Architecture for Service Discovery in the IoT
   4.4 Lightweight Service Discovery in Low-power IoT Networks
   4.5 Implementation Results

5. **Security and Privacy in the IoT** **(8 Hrs.)**
   5.1 Security Issues in th IoT
   5.2 Security Mechanisms in the IoT
   5.3 Privacy Issues in the IoT

6. **Cloud and Fog Computing for the IoT** **(7 Hrs.)**
   6.1 Cloud Computing
   6.2 Big Data Processing Pattern
   6.3 Big Stream
   6.4 Big Stream and Security
   6.5 Fog Computing and the IoT

7. **The IoT in Practice** **(8 Hrs.)**
   7.1 Hardware for the IoT
   7.2 Software for the IoT
   7.3 Vision and Architecture of a Testbed for the Web of Things
   7.4 Wearable Computing for the IoT
   7.5 Effective Authorization for the Web of Things

Laboratory Work:

The laboratory work includes implementing the concepts in above mentioned chapters.

Text/Reference Books:

1. Internet of Things: Architectures, Protocols and Standards; Simone Cirani, Gianluigi Ferrari, Marco Picone, and Luca Veltri: This edition first published 2019 © 2019 John Wiley & Sons Ltd
2. Internet of Things (IoT): Principles, Paradigms and Applications of IoT (English Edition)by Dr Kamlesh Lakhwani, Dr Hemant Kumar Gianey, Joseph Kofi Wireko, Kamal Kant HiranISBN-13978-9389423365Publication date: February 27, 2020
3. Fundamentals of Internet of Things: For Students and Professionals; F. John Dian: ISBN: 978-1-119-84729-8, December 2022, Wiley-IEEE Press

Blockchain Technology

Title: Blockchain Technology **Full Marks:** 60+40
Course No: CSITE.666 **Pass Mark:** 30+20
Nature of the Course: Theory + Lab **Credit Hrs:** 3

Course Description:
This course is designed to provide students with a comprehensive understanding of concept of Blockchain Technology. This course covers different aspects including fundamentals concept of block chain technology, evolution of block chain, application areas of blockchain, architecture of block chain, Crypto-currency and Bitcoin, working mechanism of Bitcoin, concept of Ethereum and Smart Contracts, Platforms and Frameworks for block chain, and Practice in block chain technology.

Course Objectives:
This course aims to achieve the following objectives:

- To introduce the fundamental concepts of block-chain technology.
- To understand the architecture, design, and applications of block-chain.
- To explore the use of block-chain in various domains.
- To familiarize students with smart contracts and decentralized applications.

Course Contents

Unit 1: Introduction to Blockchain (6 Hrs.)

History and Evolution of Blockchain, Key Concepts: Distributed Ledger, Decentralization and Cryptography, Types of Blockchain: Public, Private, Consortium, Use Cases: Finance, Supply Chain, Healthcare

Unit 2: Block chain Architecture and Components (8 Hrs.)

Blocks, Transactions, and Consensus Mechanisms, Hash Functions and Merkle Trees, Mining and Nodes: Types and Roles, Security Features: Immutability, Anonymity

Unit 3: Crypto-currency and Bit-coin (8 Hrs.)

Introduction to Crypto-currency, Bit-coin: Working Mechanism, Mining, Wallets; Challenges of Bit-coin: Scalability and Energy Consumption; Case Study: Bit-coin Network

Unit 4: Ethereum and Smart Contracts (8 Hrs.)

Overview of Ethereum; Smart Contracts: Concept and Development; Tools for Smart Contracts: Solidity Basics; Decentralized Applications (DApps): Architecture and Examples

Unit 5: Blockchain Platforms and Frameworks (6 Hrs.)

Overview of Popular Platforms: Hyperledger, Corda, Polkadot; Comparison of Block chain Frameworks; Interoperability and Scalability Solutions

Unit 6: Blockchain in Practice (6 Hrs.)

Blockchain in Supply Chain Management; Blockchain in Voting Systems; Challenges and Future Trends in Block chain; Ethical and Legal Implications

Laboratory Work:
The laboratory work includes implementing the concepts in above mentioned chapters.

Text/ Reference Books

1. "Blockchain Basics: A Non-Technical Introduction in 25 Steps" by Daniel Drescher
2. "Mastering Blockchain" by Imran Bashir
3. "Blockchain Revolution" by Don Tapscott and Alex Tapscott
4. "Ethereum and Solidity: The Complete Developer's Guide" by Ritesh Modi